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Prey specificity of the venom of the ctenid spider *Cupiennius salei* (Araneae, Ctenidae)

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Prey specificity of the venom of the ctenid spider *Cupiennius salei* (Araneae, Ctenidae). - The extremely different susceptibility of arthropods to the venom of *C. salei* is explained by a varying K+/Na+ ratio or by different contents of taurine or histamine or other synergistic resp. inhibitive substances in the hemolymph of the target prey items.

Key-words: Spider venom – peptide toxins – LD 50 – prey selectivity.

INTRODUCTION

The ctenid spider Cupiennius salei is a polyphagous species. It preys under natural conditions – as far as the few observations can be generalised – on a wide spectrum of prey items (Barth & Seyfarth 1979). Feeding experiments under laboratory conditions with a wide range of potential prey groups in Europe confirm these results and show *C. salei* to have the widest feeding niche breadth among 6 families of wandering spiders tested (Nentwig 1986). With this knowledge one would expect that the venom of this spider acts on a wide range of arthropods in a more or less similar manner. First tests of the sensitivity of arthropods to the venom of *C. salei* showed, however, that there are large differences among several common prey taxa (Studer & Nentwig 1993). Since these unexpected results could even suggest a specialisation of the venom we present here some results and interpretations which may help to understand such a contradictory situation.

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MATERIAL AND METHODS

To investigate the effect of the venom of *C. salei* on insects we regularly milked venom from our laboratory stock. By injecting various amounts of this venom into insects we got a measure for the susceptibility of the insects to the spider venom. The calculated LD 50, that is the lethal dose of venom which kills 50% of the experimental group, is a common figure to do such comparisons. Technical aspects of spider rearing, biochemical venom analysis and LD 50 are described in Malli *et al.* (1991) and Kuhn-Nentwig *et al.* (1994).

RESULTS AND DISCUSSION

Our tests with 20 arthropod and one vertebrate species show that the *C. salei* venom is effective in all cases but we found remarkable differences in the susceptibility of the investigated animals. They cover a range of 5 log units with white mice and flies being the most sensitive animals (LD 50 < 0.02 nl crude venom per mg body weight) and some roaches, beetles and ants being very resistant (> 4 nl venom, highest value 24 nl). Many other groups (most roaches, spiders, isopods, stick insects, moths, lacewings and crickets) are in between. There are several ways to explain these results.

Prey palatability. One possible interpretation could be that the venom had been developed or evolved by the spider to subdue the most suitable prey groups and that those taxa which are no good food are less sensitive because the venom had not been evolved for them. Feeding experiments, however, show that the acceptance rate does not explain the wide range of LD 50 values. Some ants (*Formica rufa*, *Lasius niger*, *Messor rufitarsis*, *Myrmica* sp.) and beetles (*Agelastica alni*, *Tenebrio molitor*) which demand high doses of venom are eaten by *C. salei* only at medium or even low acceptance rates. At least 4 arthropod groups (the roaches *Blaberus* sp., *Blatta orientalis* and *Nauphoeta cinerea*, the crickets *Acheta domesticus*, *Gryllus* sp. and *Grillodes sigillatus*, the stick insects *Carausius morosus* and the spiders *Cupiennius salei* itself), however, are in the same susceptibility range and represent highly acceptable prey items. The nearly always refused lacewing *Chrysoperla carnea* counts among the medium sensitive insects. Additionally, characters such as ,"suitable" or "palatable" are difficult to interpret since they do not represent a physiological mechanism for venom resistance.

Ion concentration in the insect hemolymph. The most active toxin in the venom of C. salei CSTX-1, is inhibited by K+ but not by Na+. So, high K+ concentrations prevent envenomation, and a varying ratio of K+ to Na+ in an insect hemolymph can be a possible explanation for the different susceptibility of these arthropods. Most insects which have a medium to high K+ concentration (e.g. the crickets *Acheta domesticus* and *Gryllus* sp., the stick insect *Carausius morosus*. *Cupiennius salei* itself, the roach *Nauphoeta cinerea* and the ant *Formica rufa*) are also less sensitive to

the toxin. Additionally, there are some within-group effects which can be explained by this overall scheme. Two cricket species (*Acheta domesticus* and *Gryllus* sp.) e.g., have a high K+ concentration and show a high LD 50 value (this means that they are relatively venom resistant), but a third cricket species (*Grillodes sigillatus*), the most sensitive one) has a low K+ concentration (which would explain its toxin sensitivity).

A good correlation for all arthropods does neither exist for K+ nor for Na+, probably because the physiology of insects is too different. The ratio K+/Na+, however, yields a more uniform value which is considerably good correlated with the sensitivity (measured as LD 50) ($Y = 14.092 / (x + 1.032)$, Quasi-Newton test, $p < 0.05$).

Additional synergisms. Our potassium theory gives acceptable explanations within groups but still does not explain the whole story because we find sensitive and resistant prey taxa at all LD 50 levels. We therefore searched for other substances which modulate the effects of some toxins. Since the crude venom of *C. salei* is a multicomponent system which contains a mixture of dozen of substances of differing modes of action our limited investigations have probably discovered only some of the potential effects. Beside many toxic peptides the crude venom of *C. salei* contains polyacyl amines, a hyaluronidase, histamine, several amino acids including the unusual taurine and many other low molecular substances (Kuhn-Nentwig *et al.* 1994). LD 50 biotests showed that the toxicity of CSTX-1 increases in the presence of taurine by 37% and when histamine is added by 65%. A high content of these low molecular substances (> 5 mM taurine or > 0.1 mM histamine) in an insect would for example explain a higher sensitivity to the venom. Unfortunately in most insects we do not know the taurine or histamine concentration in their hemolymphs but such investigations are in preparation.

In conclusion we think that the selectivity of the venom of *C. salei* is probably no process primarily driven by the spiders' evolutionary forces but caused by multiple physiological conditions in the prey items. The ratio of K+/Na+ (or other ions) offers some explanation possibilities, but other substances will certainly add to this effect. These can be taurine and histamine but also further hitherto unidentified substances may show additional synergistic effects.

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